EE 303
02/12/08

Next time
Bring a
copy of
tentative
papers.

Standard notation in electronics

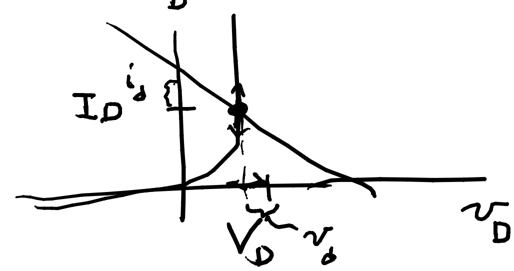
x_Y = variable x, total value for y

X_Y = bias value of X for y

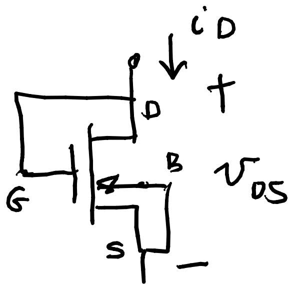
x_y = signal value of x for y

Ex: for drain current

$i_D = I_D + i_d$



MOS transistor as a diode



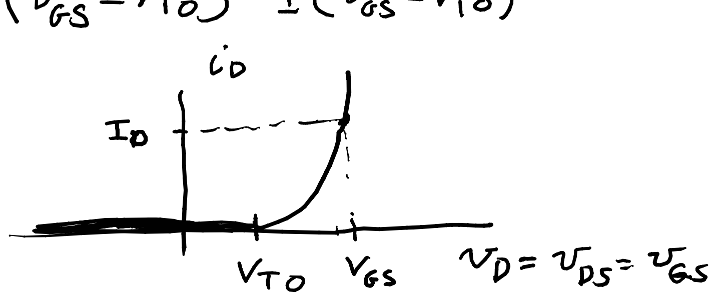
$v_{DS} = v_{GS}$

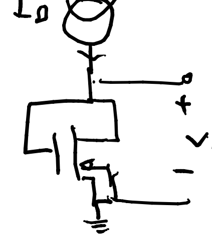
in saturation if $v_{GS} - V_{TO} \leq v_{DS}$

$v_{DS} - V_{TO} \leq v_{DS}$

∴ if $V_{TO} > 0$ this is always in saturation

$$i_D = \frac{KP}{2}\frac{W}{L}(v_{GS} - V_{TO})^2 \, 1(v_{GS} - V_{TO})$$

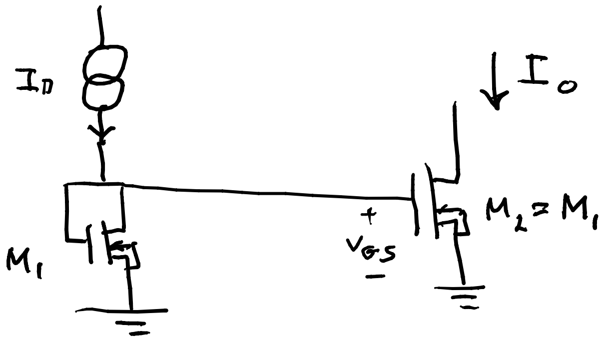




$$v_D = V_{TO} + \sqrt{\frac{I_D}{\frac{KP}{2}\frac{W}{L}}}$$

↑ ignore − sign

a current mirror



∴ if in saturation the (two) $i_{D_1} = i_{D_2}$ (are the same)

(& if $\lambda \approx 0$)

$\Rightarrow I_o = I_D$

requires enough bias voltage on M_2 to keep $V_{DS_2} \geq V_{GS} - V_{TO}$

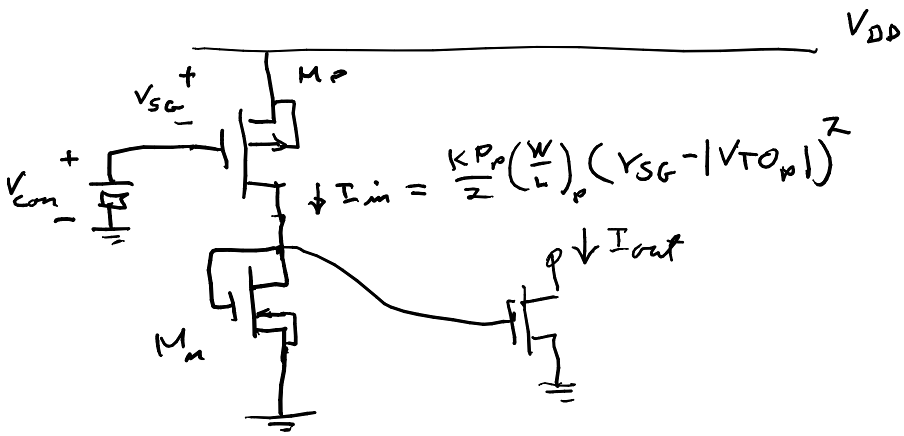
if $M_2 \neq M_1$; $i_{D_2} = \frac{KP}{2}\left(\frac{W}{L}\right)_2 (v_{GS} - V_{TO})^2$

$i_{D_1} = \frac{KP}{2}\left(\frac{W}{L}\right)_1 (v_{GS} - V_{TO})^2$

if on same chip as M_1, $KP_2 = KP_1 = KP$

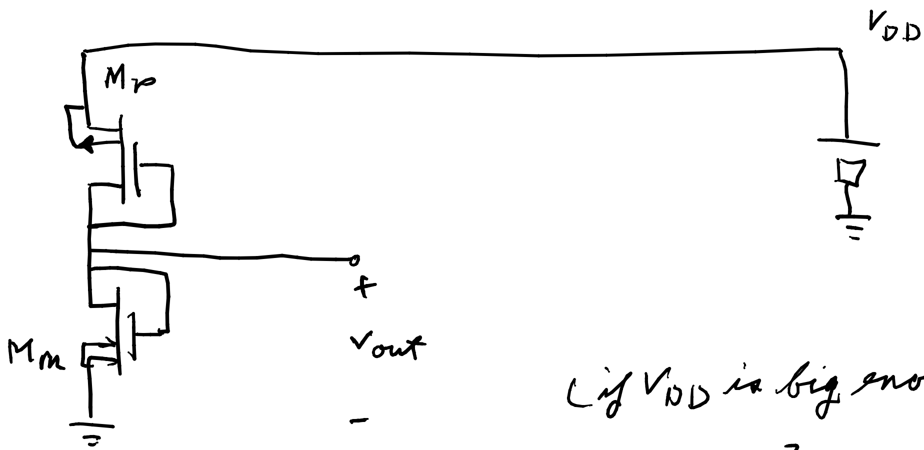
$V_{TO_1} = V_{TO_2} = V_{TO}$

$\therefore \quad \frac{i_{D_2}}{i_{D_1}} = \frac{(W/L)_2}{(W/L)_1} \Rightarrow \frac{I_o}{I_{in}}$



$I_{in} = \frac{KP_p}{2}\left(\frac{W}{L}\right)_p (V_{SG} - |V_{TO_p}|)^2$

if in saturation (can guarantee by V_{DD} large enough



(if V_{DD} is big enough to turn on)

$$i_{D_n} = -i_{D_p}$$

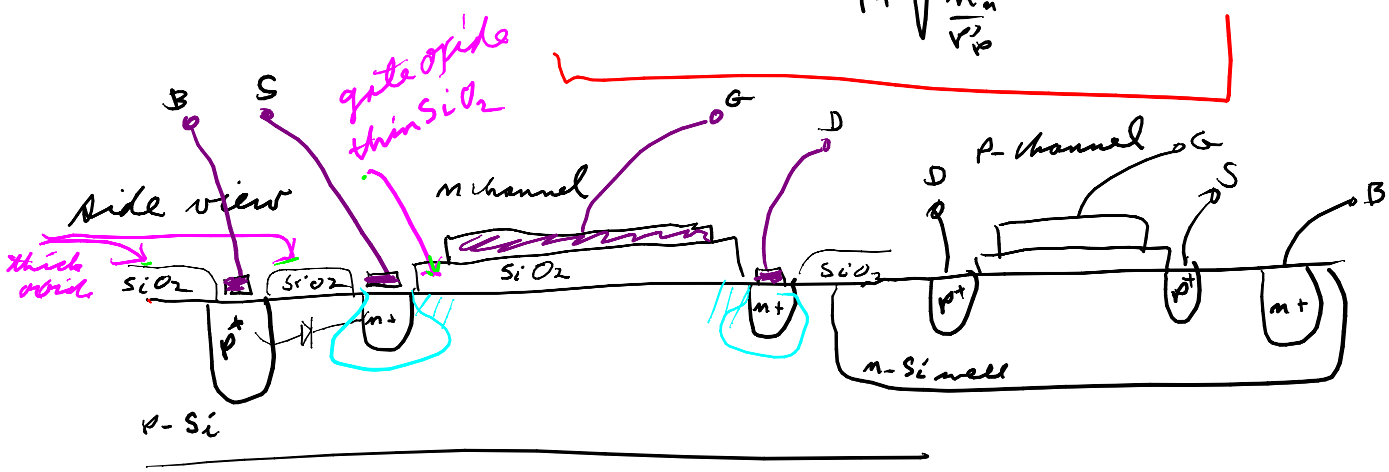
$$i_{D_n} = \frac{KP_n}{2}\left(\frac{W}{L}\right)_n (V_{out} - V_{TO_n})^2 = k'_n (V_{out} - V_{TO_n})^2$$

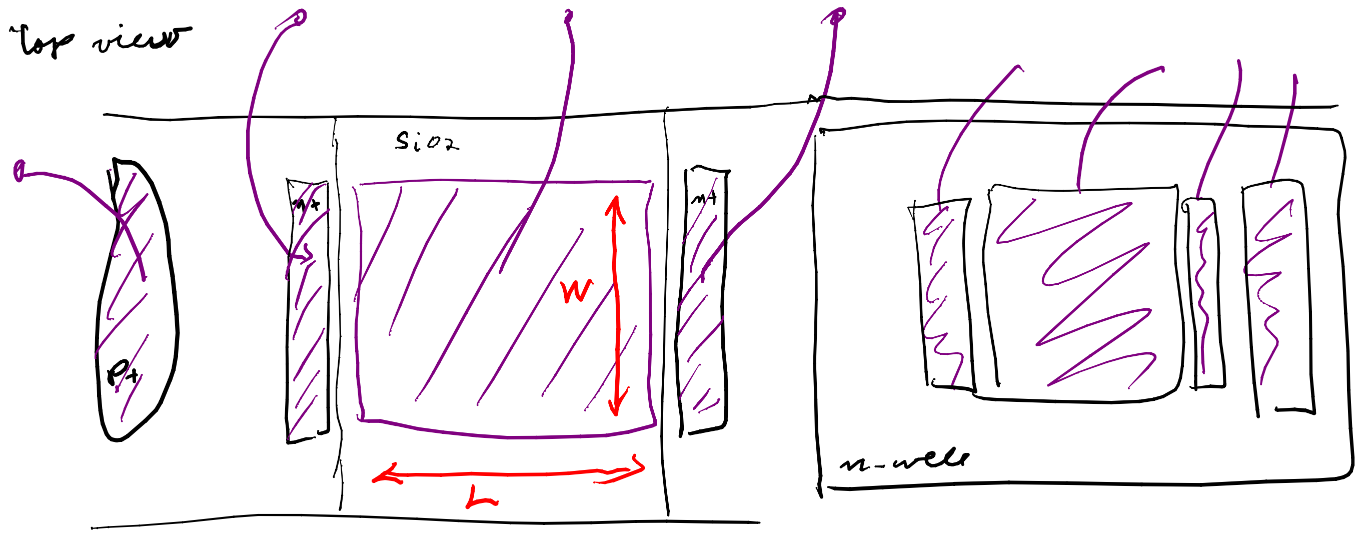
$$-i_{D_p} = \frac{KP_p}{2}\left(\frac{W}{L}\right)_p (V_{DD} - V_{out} - |V_{TO_p}|)^2 = k'_p (V_{DD} - V_{out} - |V_{TO_p}|)^2$$

$$k'_n (V_{out} - V_{TO_n})^2 = k'_p (V_{DD} - V_{out} - |V_{TO_p}|)^2$$

$$\sqrt{\frac{k'_n}{k'_p}}(V_{out} - V_{TO_n}) = + (V_{DD} - V_{out} - |V_{TO_p}|)$$

$$V_{out} = \frac{V_{DD} - |V_{TO_p}| + \sqrt{\frac{k'_n}{k'_p}}\, V_{TO_n}}{1 + \sqrt{\frac{k'_n}{k'_p}}}$$




Top view
SiO2
n+
n+
W
L
p+
n-well